Geo-Targeting Method Using Cell Radio Frequency (RF) Propagation

September 1st, 2016

Making Connections that Matter®

COMTECH TCS
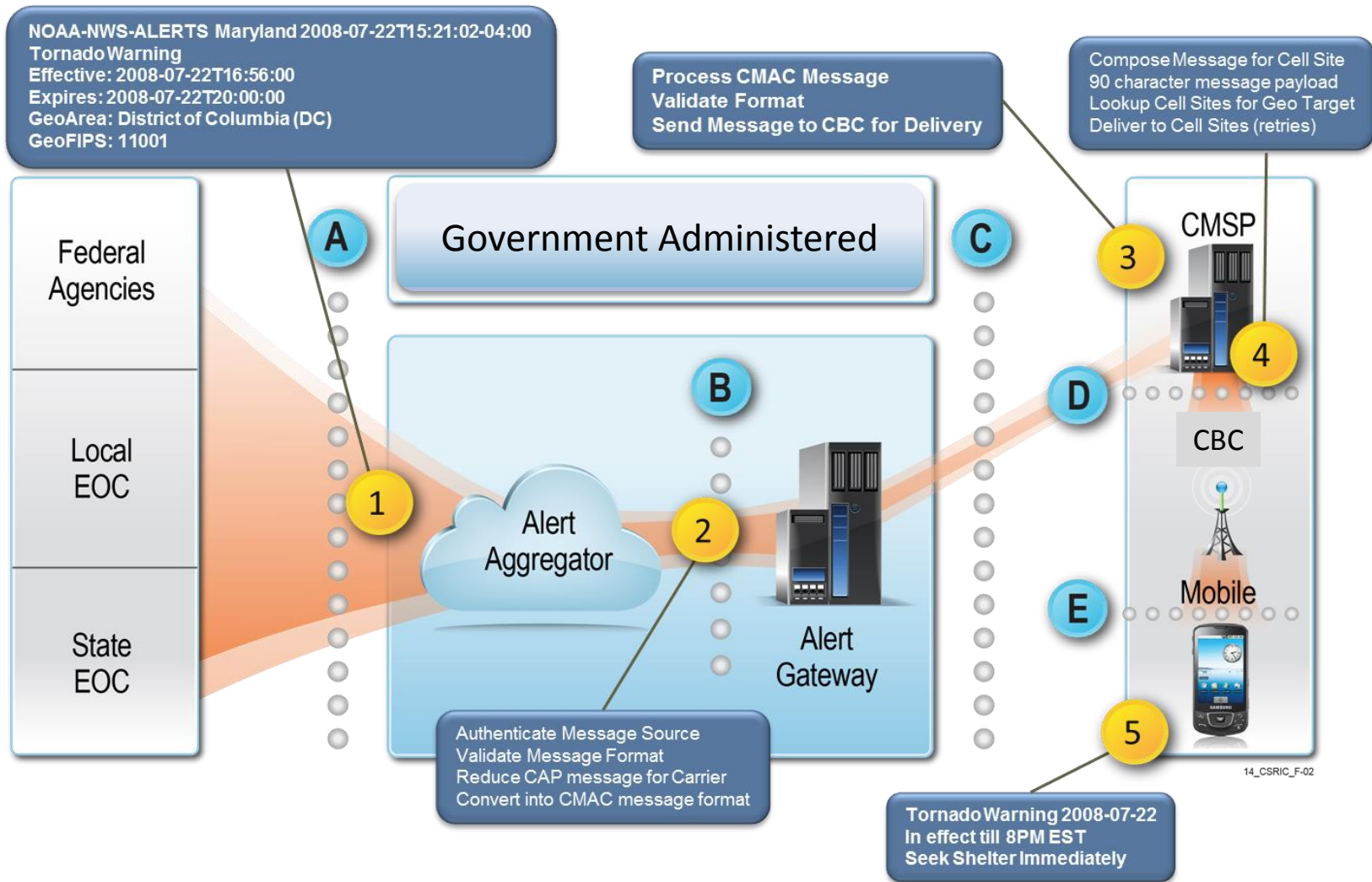*Advanced Communications Solutions℠*

Agenda

- Who is Comtech/TCS

- Background

- Research Objectives

- Basic Definition

- Algorithm Overview

- Testing Activity

- Results

- Conclusion

Who is Comtech/TCS

» Formerly TeleCommunication Systems Inc. Founded 1987 in Annapolis, Maryland

» Government Solutions Group

  » Mission-Critical Communication Solutions

» Commercial Solutions Group

  » SMSC, LBS, Enterprise Messaging, Cyber Security, Public Safety (E911, WEA)

  » Presence in over 15 Nations and 60 Mobile Operators across the Globe

» Certifications include ISO 9001:2008, ISO 27001:2005, and TL 9000

» Acquired by Comtech February 2016

Wireless Emergency Alerts (WEA) Overview

NOAA-NWS-ALERTS Maryland 2008-07-22T15:21:02-04:00
Tornado Warning
Effective: 2008-07-22T16:56:00
Expires: 2008-07-22T20:00:00
GeoArea: District of Columbia (DC)
GeoFIPS: 11001

Process CMAC Message
Validate Format
Send Message to CBC for Delivery

Compose Message for Cell Site
90 character message payload
Lookup Cell Sites for Geo Target
Deliver to Cell Sites (retries)

Government Administered

Federal Agencies

Local EOC

State EOC

Alert Aggregator

Alert Gateway

CMSP

CBC

Mobile

Authenticate Message Source
Validate Message Format
Reduce CAP message for Carrier
Convert into CMAC message format

Tornado Warning 2008-07-22
In effect till 8PM EST
Seek Shelter Immediately

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Comtech TCS Involvement with U.S. WEA

TCS is a trusted supplier to FEMA for emergency disaster recovery programs including the WEA.

- TCS is a CMSP Gateway (<u>Hosted</u>) provider with multiple mobile carriers connected to the WEA platform for nationwide alerting.

- TCS also has multiple Mobile Carriers' <u>In-Network</u> deployments.

- We have extensive experience in on-boarding mobile carriers on the CMSP platform.

- TCS is provider of the WARN Gateway system for PBS (Public Broadcast Station).

- Highly respected provider for Public Safety for E911 and NG911.

Background

- CMAS (WEA) Went live April 2012 with County-Level Granularity Geo-Targeting

- WEA Stakeholders (DHS, FEMA, NOAA etc.) recognized the need for better granularity

- The research was conducted under contract with the U.S. Department of Homeland Security Science and Technology Directorate. In November 2013, DHS awarded TCS a contract to investigate the feasibility of using enhanced geo-targeting algorithms better than minimum requirement.

- The project was divided in two phases.

  – Phase 1 - Evaluated the use of predicted cellular RF coverage areas in geo-targeting algorithm in lab environment, completed in May 2014

  – Phase 2 – Field Testing in Live Network of Phase 1, completed April 2016

Research Objectives

- To Measure Improvement Using RF Propagation Model Over Existing Method in Production Environment

- To Improve Geo-Targeting Accuracy minimizing "over-alerting" and "under-alerting" scenarios

- To Maintain compatibility with the current message definition and legacy mobile devices

- Optimize existing granularity to allow much smaller alert target areas such as campus shooting, chemical spill, or airport bomb threat

➢ **Maximize public warning reachability, while minimizing irrelevant alerts.**

Basic Concepts – Cell Tower vs Cell Sector
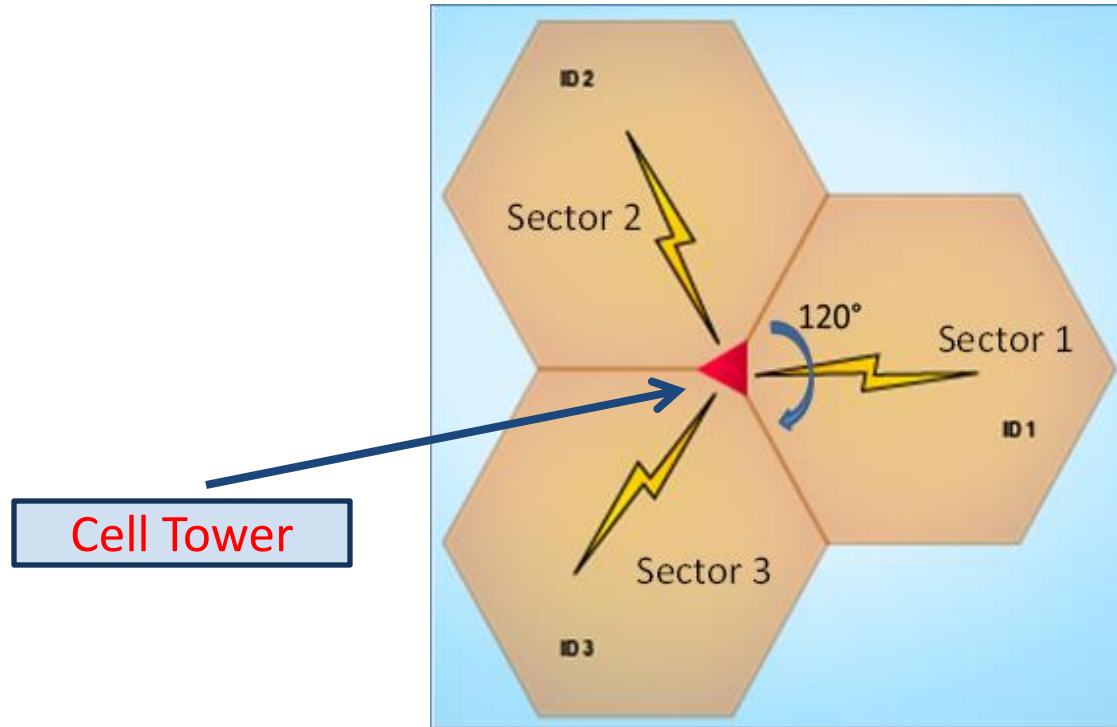
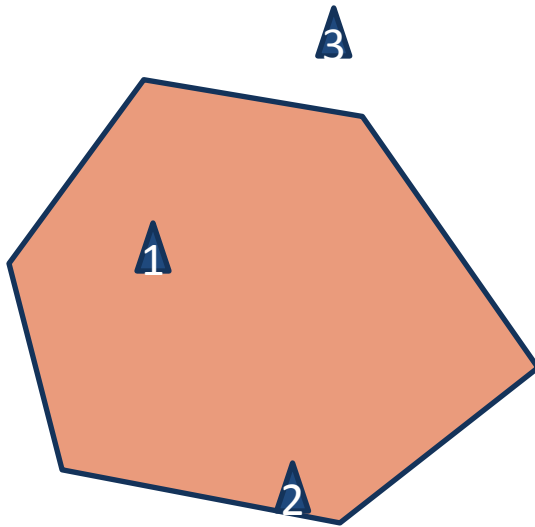Note: some towers have up to 6 sectors

Basic Concepts – RF Propagation Model
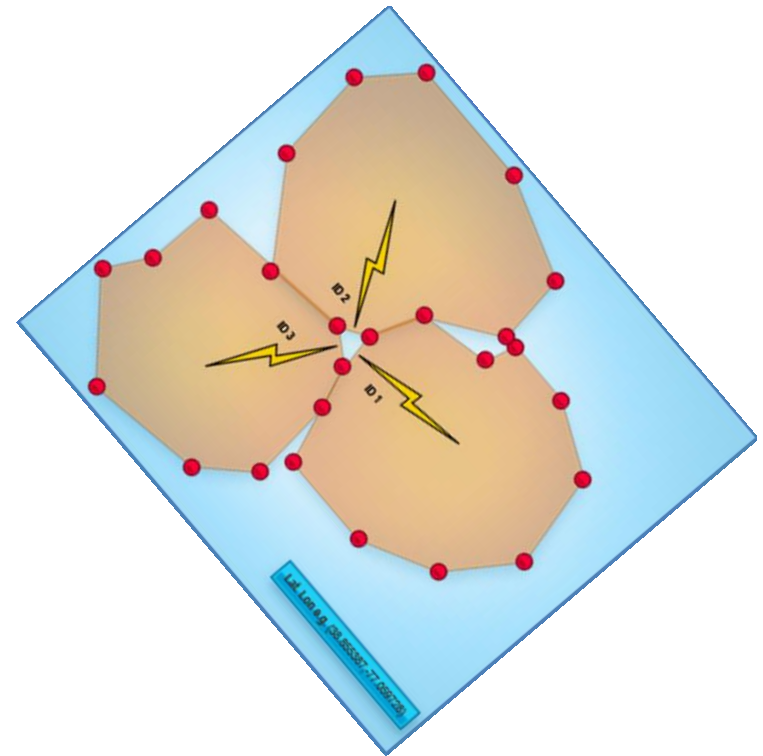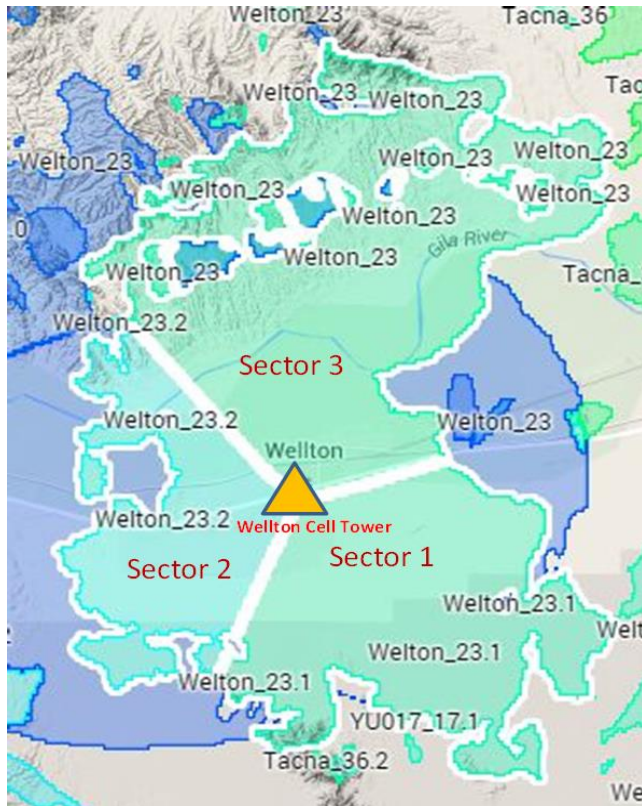
- Generated By Cell Planning Software
- Sets of Polygons with LAT/LON points
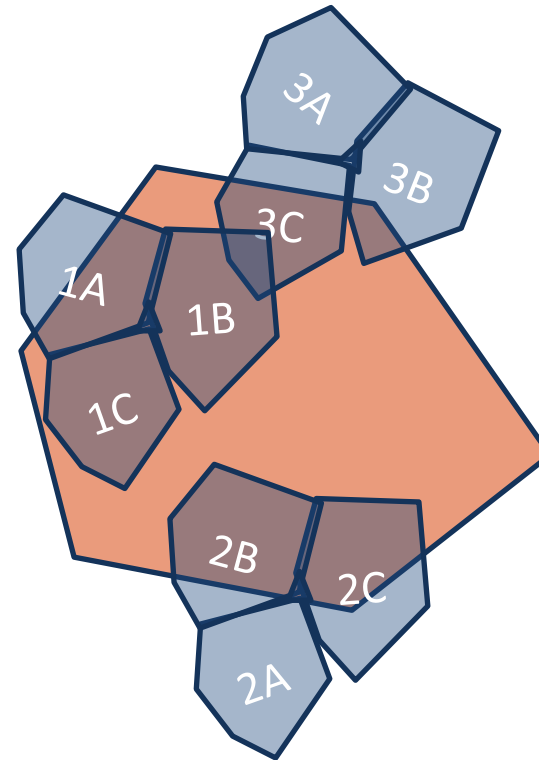- Data – Radio characteristics, terrains

- Data Set Import into DB for Each Sector
- 1 Polygon/Sector with many points
- Each Tower has 3 Polygons

Basic Concepts – Point-in Poly Vs Poly in Poly Algorithm

Point-in-Poly Algorithm
Broadcast alerts to all 3 sectors
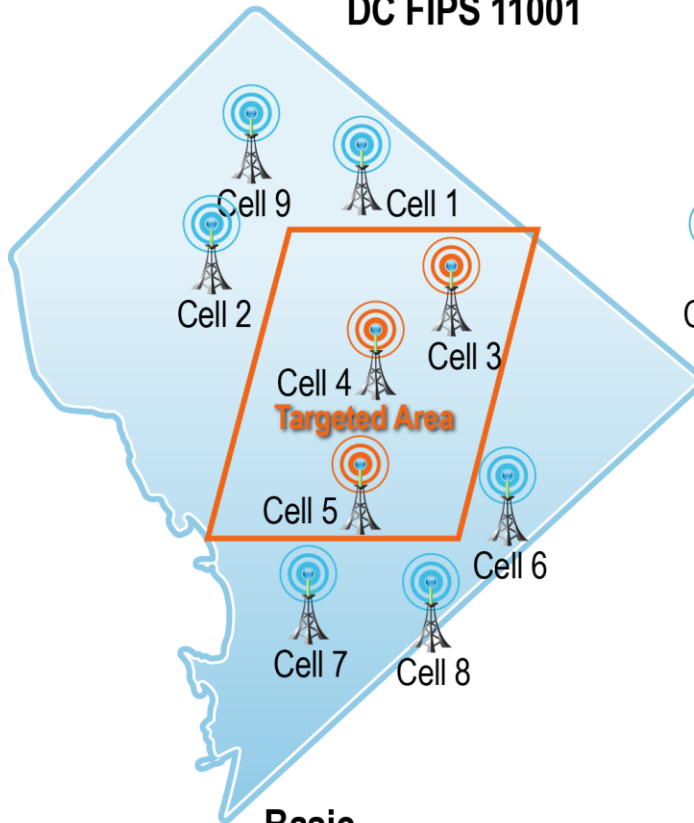For tower lat/lon inside the target area
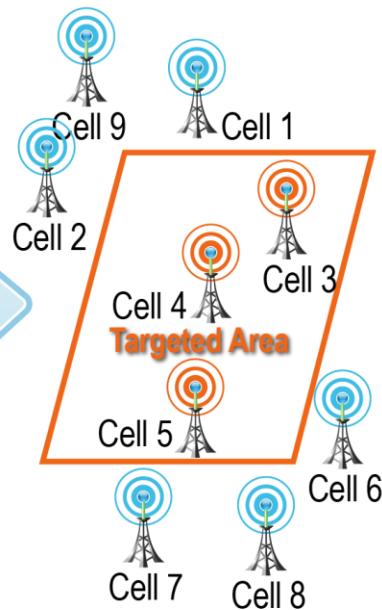
Poly-in-Poly Algorithm
Broadcast alerts to only sectors
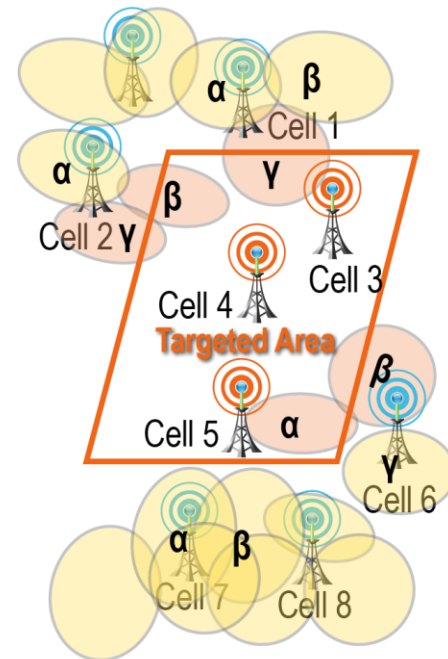Intersecting the target area

Geo-Targeting Methods
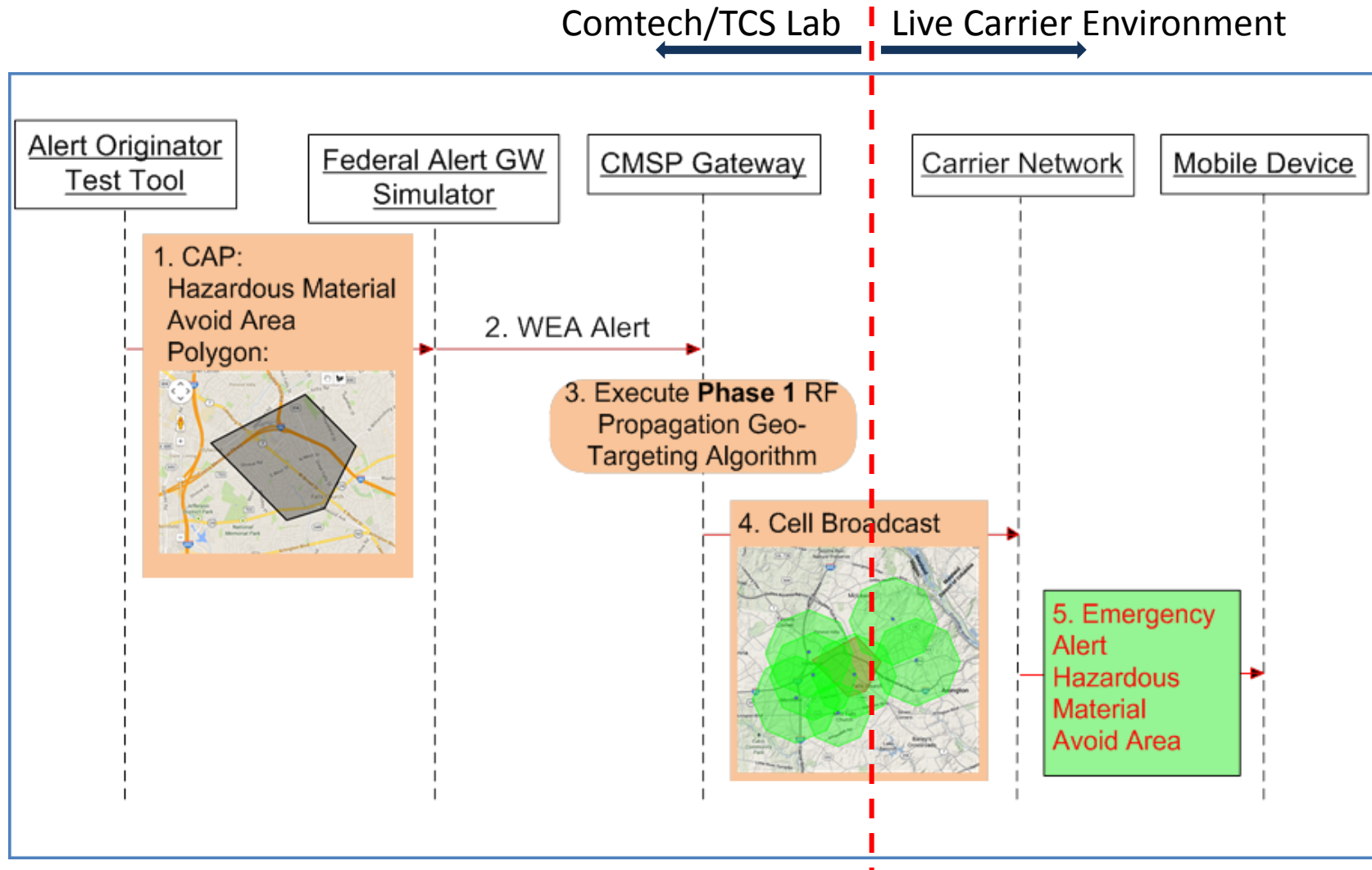

DC FIPS 11001

Basic

Point in Poly

Poly in Poly
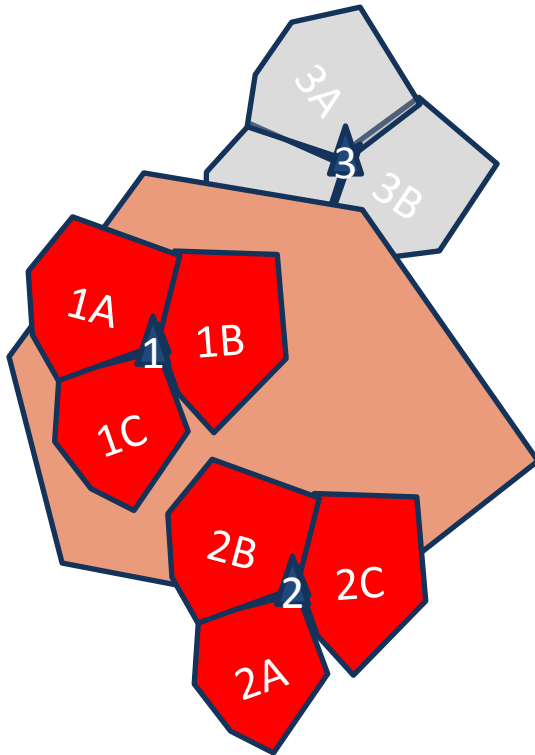
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Basic WEA Alert Use Case

Theoretical Expectation - Example

Point-in-Poly Algorithm (Tower Coord.):
Expected outcome:
Cell Broadcast List: All sectors in 1 and 2
Under Alerts: 3B,3C
Over Alerts: 2A, part of 1A,2B,2C
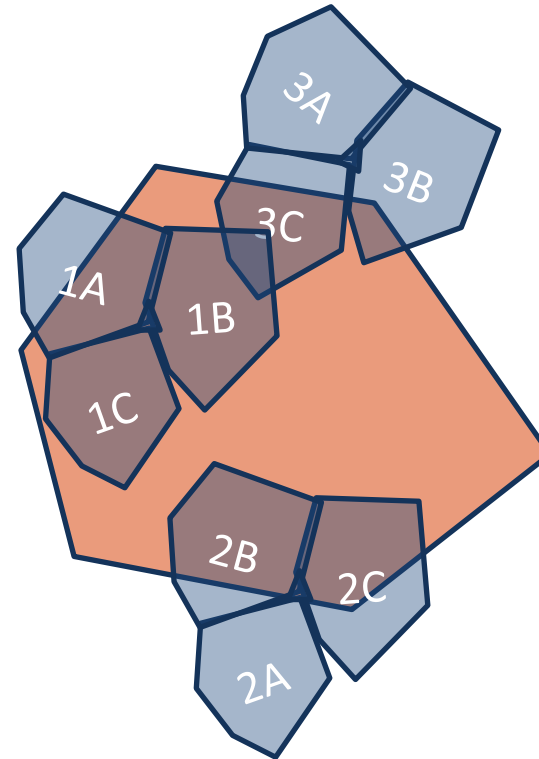
Poly-in-Poly Algorithm (RF Prop):
Expected outcome:
CBC list : 1A,1B,1C, 2B, 2C, 3C, 3B
Under Alerts: None
Over Alerts: Part of 1A, 2B,2C, 3B,3C

Enhanced Alert Area Definition Tool

- The ability to generate an alert target area and show the affected cell sectors RF coverage
- Can be used to view RF coverage during cell planning
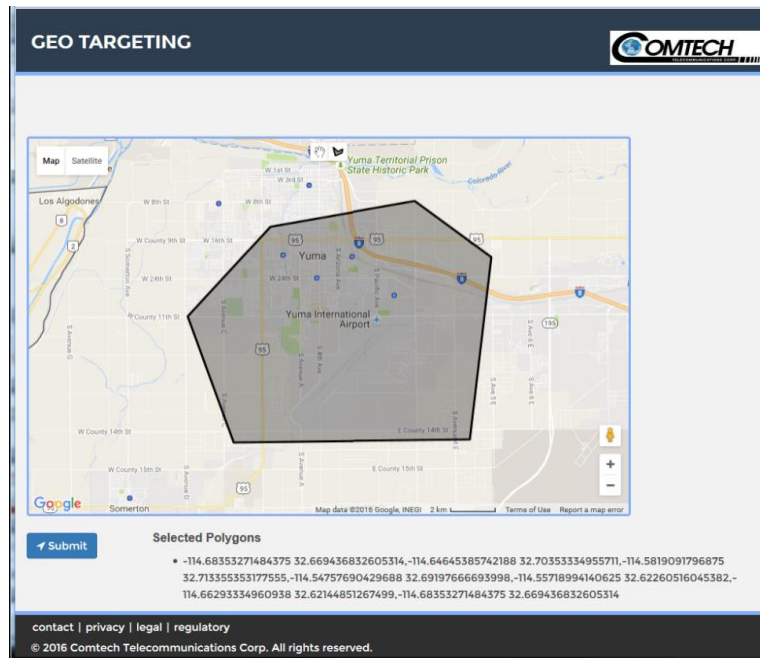
Draw Target Area

Submit
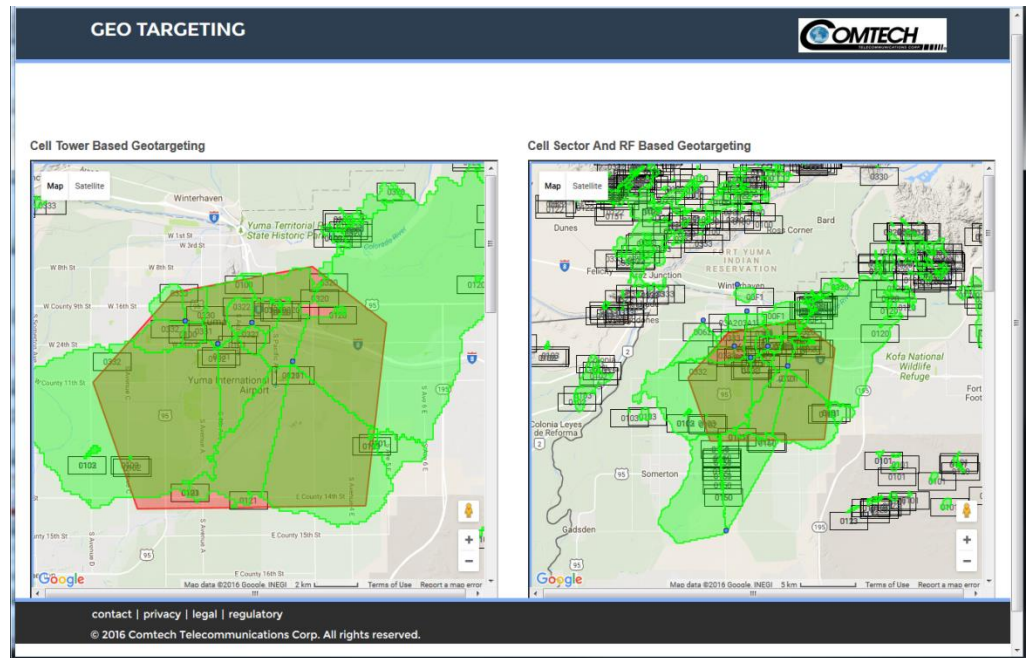
Display Affected Coverage Area

Geo-Targeting Area Cell RF Coverage Viewer

Enhanced Alert Area Definition Tool

Testing Location– YUMA, Arizona
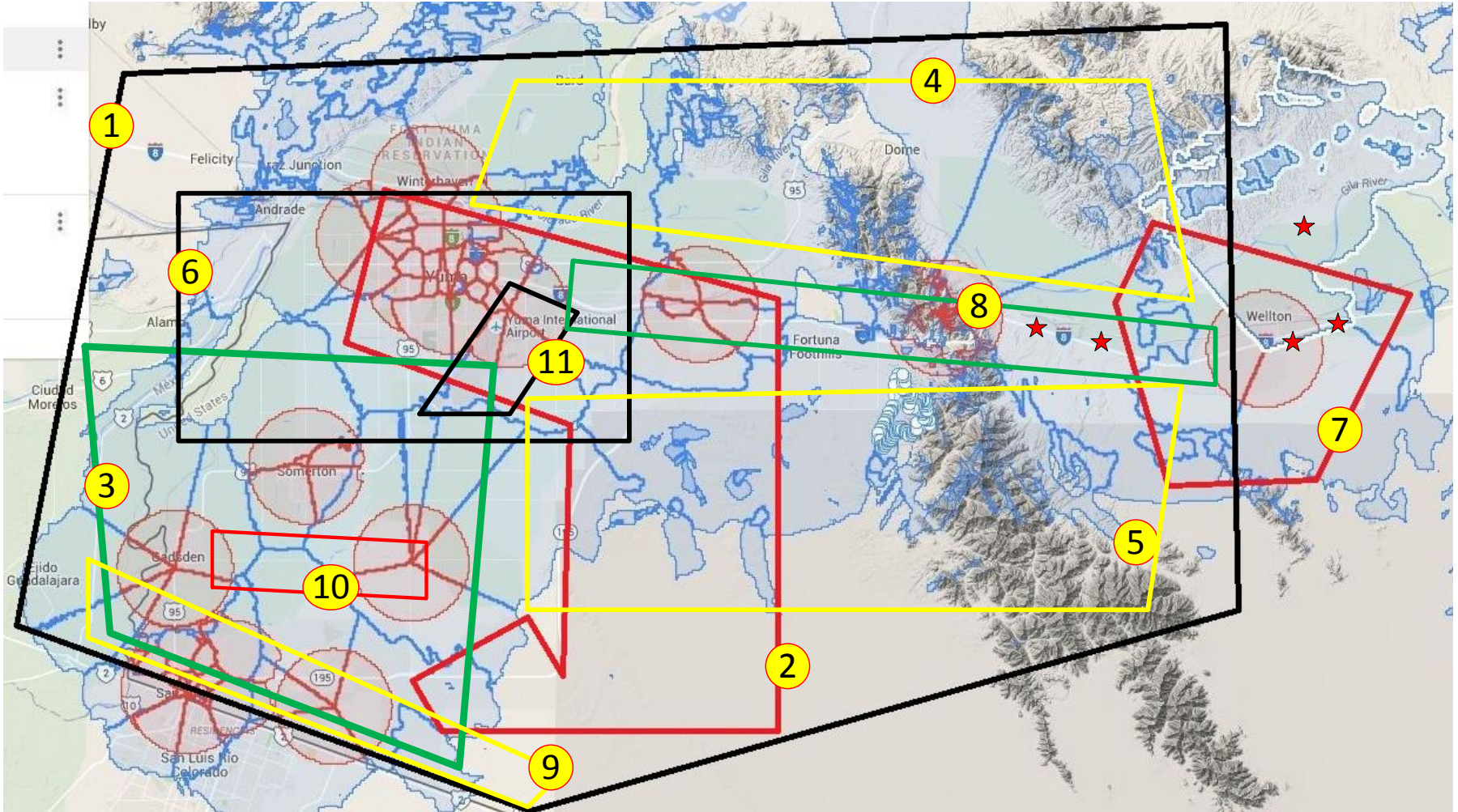
Test Results Small Target Areas

From 15 sq miles down to 30 acres (1307K ft²)
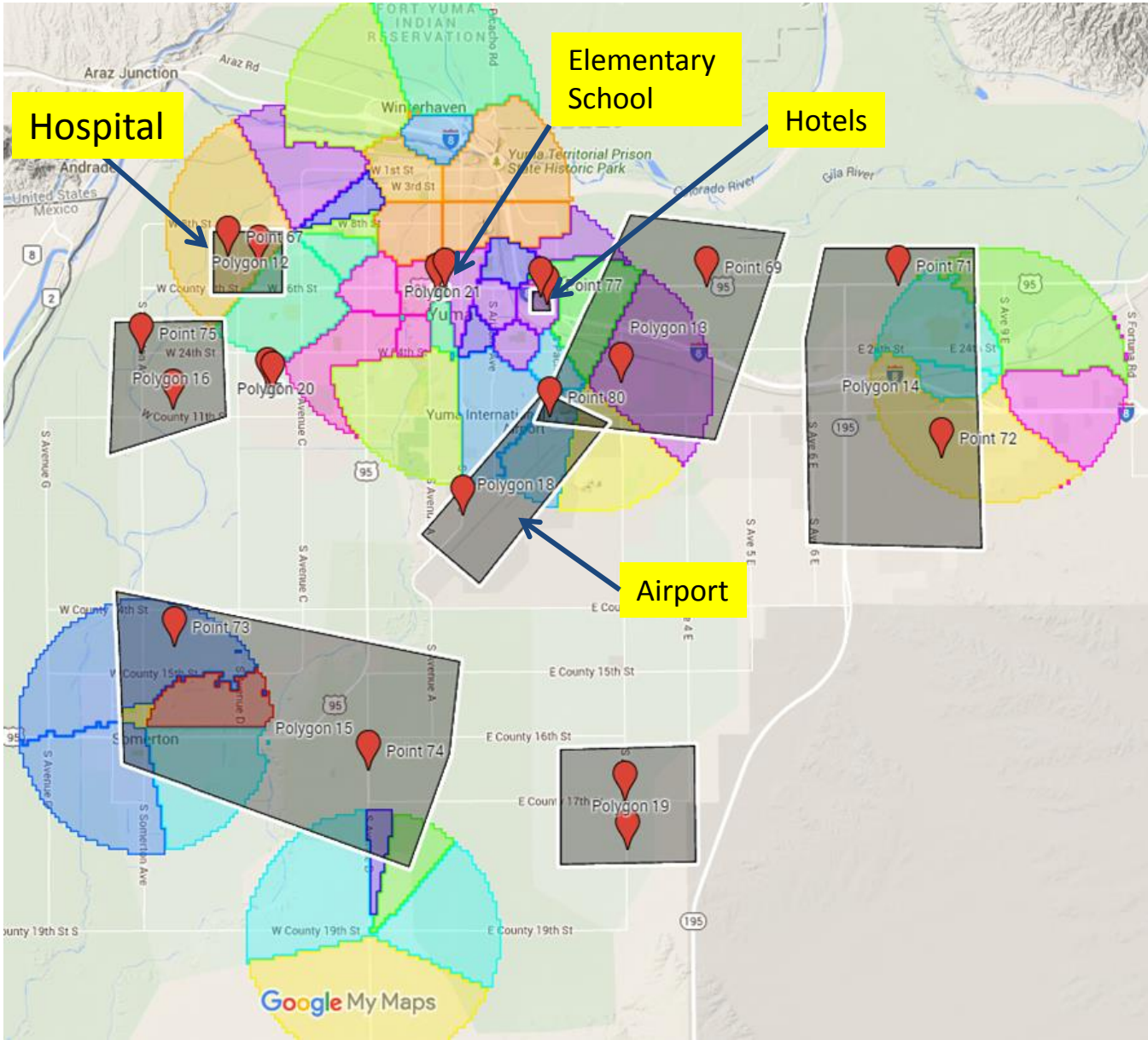
Testing Points– YUMA, Arizona
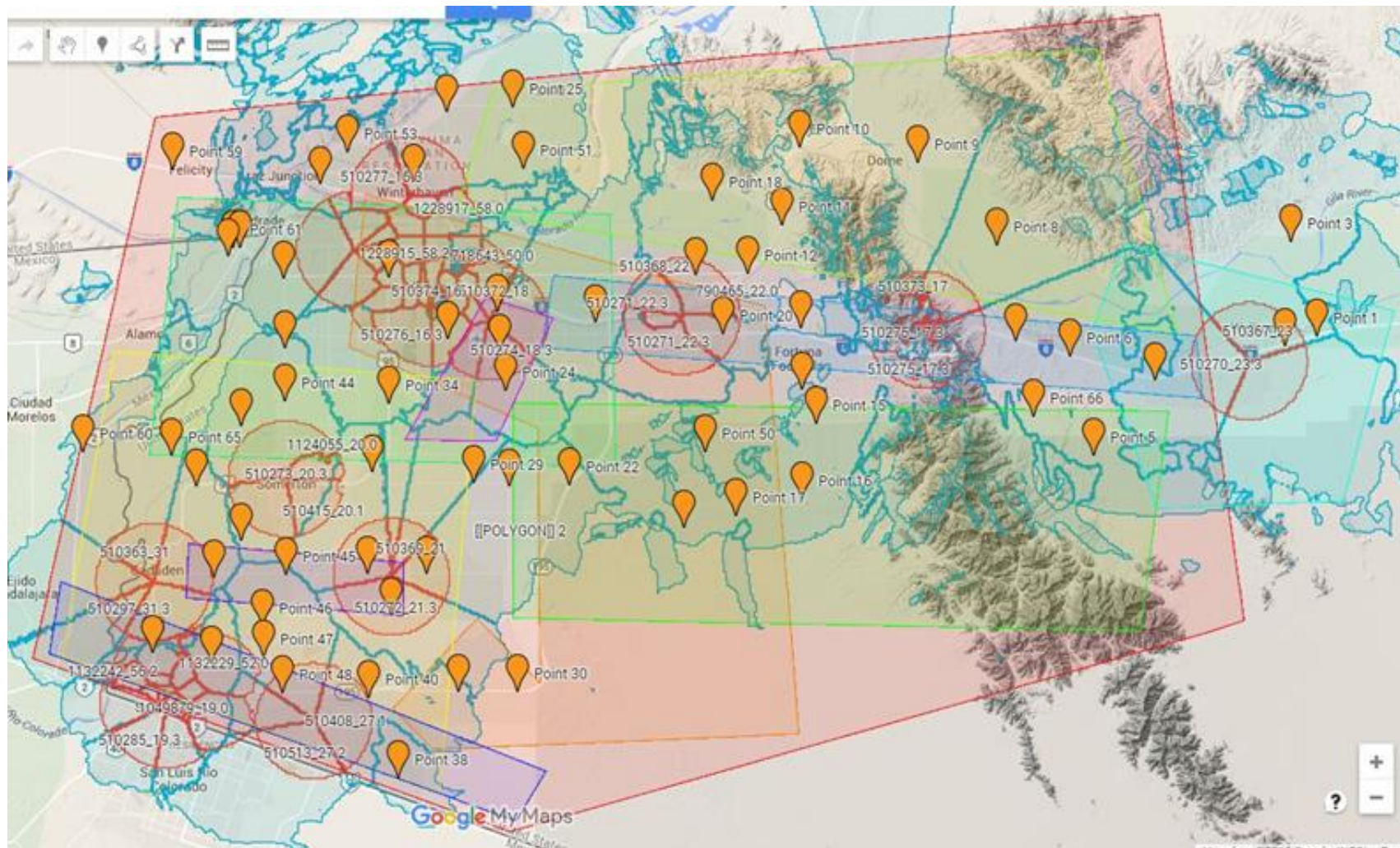
Test Input Statistics

- Number of Targeting Areas - 21

- Number of Test Points - 81

- Number of Test Alerts Sent - 244

- Number of Cell Sectors Covered – 65

- 50% of the Test Alerts for Point-in-Poly (Tower Coordinates)

- 50% of the Test Alerts for Poly-in-Poly (RF Propagation model)

Test Results Recording

- A Fail was recorded for one of the following scenarios:

  - The mobile device was inside the target area but no alert was received 15 seconds after the alert submission (under-alerting).

  - The mobile device was outside the target area but still received the alert. This represents a case of an "over-alerting" condition.

- A Success was recorded for one of the following scenarios:

  - The mobile device was inside the target area and it received the alert within 15 seconds of its submission.

  - The mobile device was outside the alert area and it did NOT receive the alert after 15 seconds of alert submission.

- Inconclusive

  - There was no coverage (no signal, or signal strength was too low) at the test point.

Test Results

| Geo-Targeting Method	Target Area Polygon	Polygon Size (Sq Miles)	Number of Desired Outcomes	Number of Over-Alerts	Number of Under Alerts (missing alerts)	Total Nuber of Tests	Success Ratio	Over-Alert Ratio	Missing Alert Ratio
Tower Lat/lon	1	861	9	0	3	12	75%	0%	25%
	2	180	9	1	2	11	82%	9%	18%
	5	163	3	0	4	7	43%	0%	57%
	3	158	12	0	5	17	71%	0%	29%
	4	153	3	0	7	10	30%	0%	70%
	6	132	13	0	2	15	87%	0%	13%
	7	66.8	3	2	0	5	60%	40%	0%
	8	51.2	5	3	1	8	63%	38%	13%
	9	34.4	3	1	2	6	50%	17%	33%
	10	13.9	5	1	3	9	56%	11%	33%
	11	13.3	4	0	0	4	100%	0%	0%
Small Areas	Avge of 9 Polygons	**5.40**	**2**	**0**	**16**	**18**	11%	N/A	89%
Total/Average%			**71**	**8**	**45**	**122**	**58%**	**7%**	**37%**
RF Propagation	1	861	9	0	3	12	75%	0%	25%
	2	180	9	2	1	11	82%	18%	9%
	5	163	6	1	0	7	86%	14%	0%
	3	158	14	1	2	17	82%	6%	12%
	4	153	7	2	0	10	70%	20%	0%
	6	132	12	1	2	15	80%	7%	13%
	7	66.8	3	2	0	5	60%	40%	0%
	8	51.2	6	2	1	8	75%	25%	13%
	9	34.4	5	1	0	6	83%	17%	0%
	10	13.9	6	3	0	9	67%	33%	0%
	11	13.3	2	2	1	4	50%	50%	25%
Small Areas	Avge of 9 Polygons	**5.40**	**13**	**0**	**5**	18	72%	N/A	28%
Total/Average%			**92**	**17**	**15**	**122**	**75%**	**14%**	**12%**

Test Results Small Target Areas

Test Point Number	Target Area Polygon	Polygon Size (Sq miles)	Time	Handset Lat	Handset Lon	Geo-targeting Type	Test Case Result	Note
67	20	0.0471	12/15/2015 16:17	32.6760115	-114.6766341	Cell Tower Lat/Lon	Fail	Mesquite Elementary
68	20	0.0471	12/15/2015 16:24	32.6753613	-114.6752608	Cell Tower Lat/Lon	Fail	No coverage
69	17	0.0915	12/15/2015 11:49	32.6949653	-114.6015751	Cell Tower Lat/Lon	Fail	Hotels
71	17	0.0915	12/16/2015 11:52	32.6966085	-114.6030772	Cell Tower Lat/Lon	Fail	
72	12	1.04	12/15/2015 16:41	32.7057723	-114.6873093	Cell Tower Lat/Lon	Fail	Hospital
74	12	1.04	12/15/2015 16:47	32.7038584	-114.6790695	Cell Tower Lat/Lon	Fail	
75	16	3.19	12/15/2015 16:31	32.6838139	-114.7105694	Cell Tower Lat/Lon	Fail	handsets camped to other cells
76	16	3.19	12/15/2015 16:04	32.6710986	-114.7019434	Cell Tower Lat/Lon	Fail	
77	18	3.55	12/15/2015 13:40	32.6471443	-114.6242666	Cell Tower Lat/Lon	Fail	
78	18	3.55	12/15/2015 13:26	32.669491	-114.6008778	Cell Tower Lat/Lon	Fail	Airport
79	19	3.9	12/15/2015 13:58	32.5824752	-114.5804501	Cell Tower Lat/Lon	Fail	
80	19	3.9	12/15/2015 14:07	32.5713369	-114.5799351	Cell Tower Lat/Lon	Fail	
81	13	8.92	12/15/2015 12:09	32.6989831	-114.5584774	Cell Tower Lat/Lon	Fail	
82	13	8.92	12/15/2015 13:14	32.6772397	-114.5816517	Cell Tower Lat/Lon	success	
83	14	12.4	12/15/2015 12:19	32.6993442	-114.5068932	Cell Tower Lat/Lon	Fail	
84	14	12.4	12/15/2015 12:42	32.6600436	-114.4954777	Cell Tower Lat/Lon	Fail	
70	15	15.5	12/15/2015 14:29	32.5892733	-114.6497154	Cell Tower Lat/Lon	Fail	
73	15	15.5	12/15/2015 14:46	32.6175447	-114.701643	Cell Tower Lat/Lon	success	
76	20	0.0471	12/15/2015 16:15	32.6760115	-114.6766341	RF Propagation	Fail	Mesquite Elementary
81	20	0.0471	12/15/2015 16:23	32.6753613	-114.6752608	RF Propagation	Fail	No coverage
82	17	0.0915	12/15/2015 11:49	32.6949653	-114.6015751	RF Propagation	success	Hotels
83	17	0.0915	12/16/2015 11:51	32.6966085	-114.6030772	RF Propagation	success	Received at second attempt
84	12	1.04	12/15/2015 16:40	32.7057723	-114.6873093	RF Propagation	success	Hospital
67	12	1.04	12/15/2015 16:46	32.7038584	-114.6790695	RF Propagation	success	
68	16	3.19	12/15/2015 16:03	32.6710986	-114.7019434	RF Propagation	Fail	handsets camped to other cells
69	16	3.19	12/15/2015 16:30	32.6838139	-114.7105694	RF Propagation	success	
70	18	3.55	12/15/2015 13:39	32.6471443	-114.6242666	RF Propagation	success	
71	18	3.55	12/15/2015 13:25	32.669491	-114.6008778	RF Propagation	success	Airport
72	19	3.9	12/15/2015 13:57	32.5824752	-114.5804501	RF Propagation	Fail	
73	19	3.9	12/15/2015 14:06	32.5713369	-114.5799351	RF Propagation	Fail	
74	13	8.92	12/15/2015 12:09	32.6989831	-114.5584774	RF Propagation	success	
75	13	8.92	12/15/2015 13:12	32.6772397	-114.5816517	RF Propagation	success	
77	14	12.4	12/15/2015 12:18	32.6993442	-114.5068932	RF Propagation	success	
78	14	12.4	12/15/2015 12:41	32.6600436	-114.4954777	RF Propagation	success	
79	15	15.5	12/15/2015 14:45	32.6175447	-114.701643	RF Propagation	success	
80	15	15.5	12/15/2015 14:28	32.5892733	-114.6497154	RF Propagation	success	

Test Results Small Target Areas

				Tower Coord	RF Propagation
Polygon Size Sq Miles (average)				5.4	5.4
Total Number of Success				2	13
Total Number of Over-Alerts				NA	NA
Total Nuner of Under Alerts (missing alerts)				16	5
Total Nuber of Test				18	18
Ratio of Success				11%	72%

Theory Versus Reality
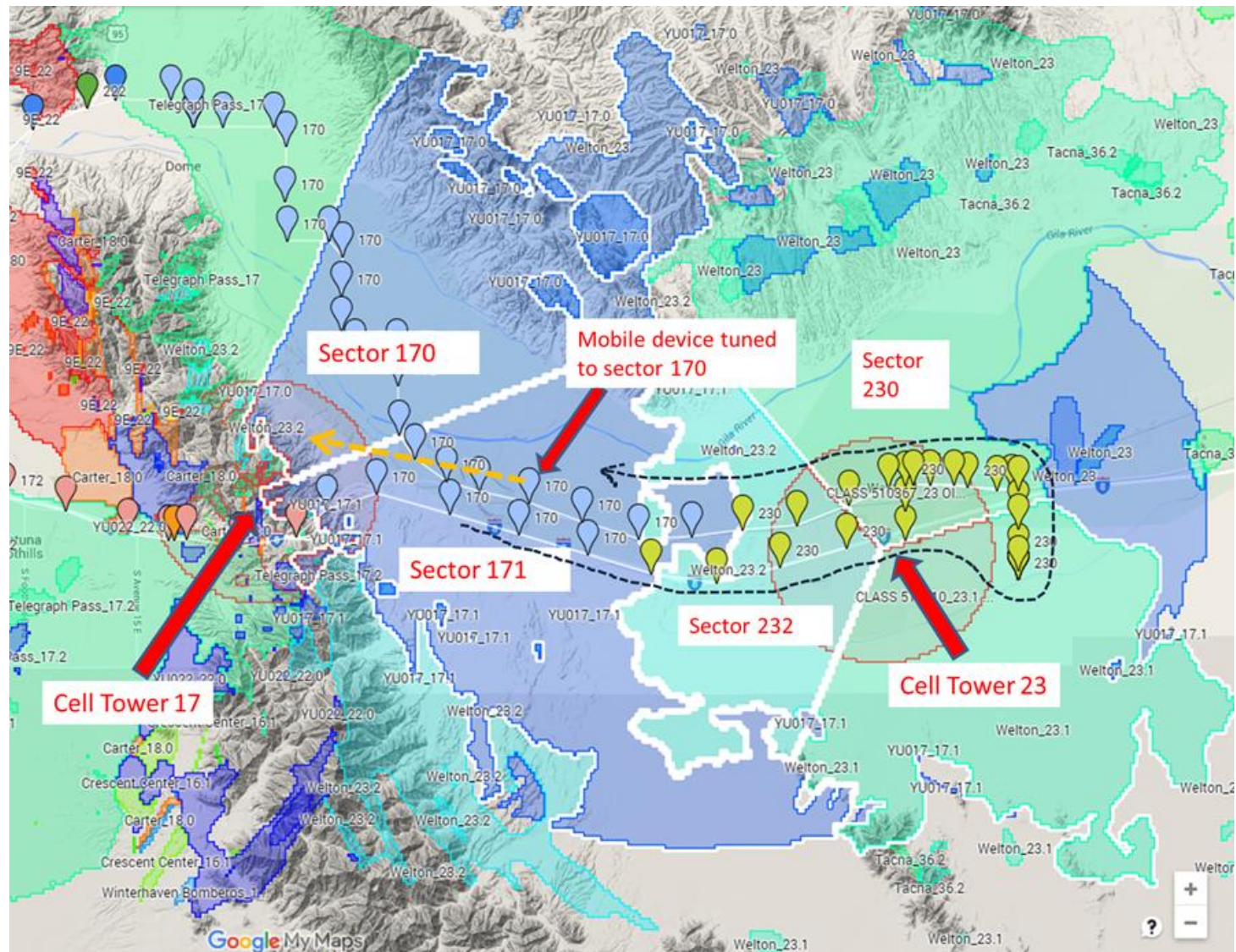
Accomplishments – WEA Advanced Features

- Location sensitive RMT test tool– RMT sent to a specific target area down to cell sector level

- Drive Testing of WEA Capability

- True Sector based geo-targeting algorithm and field tested with high performance

- The Alert Area RF Propagation Viewer Web Service for WEA - could be used to view cell RF propagation for other purposes.

Conclusion

- For Large Target Areas > 100 Square Miles both targeting methods are comparable
- As Target Areas becomes smaller RF method outperforms Tower lat/lon method
- RF method performs worse than Cell Tower method for small target area in over-alerting but limited by cell sector size
- Real-life Radio/Handset behavior varies
- RF Propagation Method Allows:
  - ➢ Targeting much smaller alert areas down to a few square miles regardless of the physical location of the cell towers
  - ➢ Geo-targeting at the cell sector granularity;
  - ➢ Enhancing reachability to the people in harm's way;
  - ➢ Enabling other alert categories to be submitted to the public because alert target area size can now be reduced significantly; and
  - ➢ Providing a solution that requires no change to the current WEA network.

Thank You

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